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The Regional Dimension of North-South Trade-Related R&D Spillovers

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Abstract

This paper examines the impact of trade with Japan, North America, and the European Union on technology diffusion and total factor productivity growth in Korea, Mexico, and Jordan. Measures of foreign research and development are constructed based on industry-specific research and development in the North, North-South trade patterns, and input-output relations in the South.

The findings show that technology diffusion and productivity gains tend to be regional. Jordan benefits mainly from trade with the European Union, Korea from trade with Japan, and Mexico from trade with North America. In other words, the dynamic version of the "natural trading partners" hypothesis holds for these countries

This paper—a product of the Trade Team, Development Research Group—is part of a larger effort in the department to understand the process of North-South technology diffusion. Policy Research Working Papers are also posted on the Web at http://econ.worldbank.org. The author may be contacted at mschiff@worldbank.org.

The Regional Dimension of North-South Trade-Related R&D Spillovers*

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1. Introduction

A developing country is likely to trade more with a country that is larger, richer and more open in the North than otherwise. Moreover, a smaller distance between the two countries is likely to result in lower trading costs between them and would also promote trade between them.

Two countries with such a strong trade relationship are typically referred to as "natural trading partners" (NTPs). To date, studies have examined the hypothesis that a regional trade agreement (RTA) is preferable when its members are NTPs. These studies, conducted in a static framework, have been unable to come to an agreement as to whether regional trade agreements (RTAs) between natural trading partners are superior or not. [1]

This paper provides a formal dynamic analysis of the hypothesis. Two versions of the hypothesis have been examined, with one referring to the large volume of trade between potential partners in an RTA, and the other referring to the small distance between them. Both versions of the hypothesis are examined here.

Specifically, the paper estimates the impact of North-South trade on technology diffusion and TFP growth in the South, and examines whether or not trade-related technology diffusion exhibits a regional dimension. In other words, we compare the impact of North-South trade between NTPs with that between non-NTPs.

[1] A number of studies, including Summers (1991) and Deardorff and Stern (1994), claim that a regional trade agreement (RTA) is less likely to generate trade diversion and is more likely to raise welfare when the RTA members already trade disproportionately with each other. Opponents of the hypothesis such as Bhagwati (1993) and Bhagwati and Panagariya (1996) argue that a RTA between a developed country and a developing country where the latter imports little from the former (e.g., because of the great distance between them) is better for the latter, the main reason being that the lower level of imports by the developing country implies a smaller revenue transfer to the developed partner when tariffs are abolished. Krishna (2003) estimates the welfare impact of trade directly and rejects the hypothesis. Schiff (2001) argues that, except for the latter study, a problem with these analyses is that they fail to include a constraint imposed by the trade relationship between the partner country and the rest of the world.

The main developed countries of the OECD are divided into three groups: Japan, Canada plus the US (referred to here as North America) and the EU. We select three countries in the South that are NTPs of one of the three OECD regions in terms of both distance and trade volume: Korea as NTP of Japan, Mexico as NTP of North America, and Jordan as NTP of the EU.[2] We find that trade-related technology diffusion and productivity gains are regional: the elasticity of TFP with respect to trade is highest for trade between Korea's (Mexico's) (Jordan's) trade in the case of trade with Japan (North America) (the EU).[3]

The remainder of the paper is organized as follows. Section 2 sets forth a brief analytical framework, Section 3 describes the data used, and Section 4 presents the empirical results. Section 5 provides an interpretation of the results, and Section 6 concludes.

2. Analytical Framework

The last 15 years have seen the development of a literature about the impact of trade on international technology diffusion and productivity. Coe and Helpman (1995) developed an empirical application of the theoretical work of Grossman and Helpman (1991) by constructing an index of "foreign R&D" that consists of the trade-weighted sum of trading partners' R&D stocks. They estimated the impact of foreign R&D on TFP

[2] Industry-level data are available for 24 developing countries. For Japan and North America, we selected, respectively, Korea and Mexico for being the closest to and trading the most with their proximate OECD trading partner. The reason for selecting Jordan is different and is discussed in Section 4.3.
[3] The fourteen EU countries included in the analysis are Austria, Belgium, Denmark, Finland, France, Germany, Italy, the Netherlands, Norway, Portugal, Ireland, Spain, Sweden, and the United Kingdom.

for OECD countries plus Israel and found a large and robust impact of foreign R&D on TFP. This seminal work led to a large number of studies.[4]

For a given industry i in country c in year t, we define the trade-related foreign R&D, *NRD*, as follows:

$$NRD_{cit}^{N} \equiv \sum_{j} a_{cij}\,\overline{RD_{cjt}^{N}} = \sum_{j} a_{cij}\left[\sum_{k}\left(\frac{M_{cjkt}}{VA_{cjt}}\right) RD_{jkt}^{N}\right], \tag{1}$$

where N indexes the three OECD regions, k indexes the member countries of OECD region N, c indexes Korea, Mexico and Jordan, j indexes industries and t indexes years.

The first part of equation (1) says that foreign R&D from region N in industry i in country c, NRD_{cit}^{N}, is a weighted sum over all industries j of $\overline{RD_{cjt}^{N}}$, with weights equal to a_{cij}, the share of industry-j imports sold to industry i (proxied by the input-output share in the empirical implementation). The second part of equation (1) says that $\overline{RD_{cjt}^{N}}$ is a weighted sum of R&D stocks RD_{jkt}^{N} of industry j in member country k of OECD region N, with weights equal to M_{cjkt}/VA_{cjt}, the imports of industry-j products from country k per unit of industry-j value added in country c (i.e., its import concentration ratio).

Following Coe et al. (1997), we do not include domestic R&D stocks in the estimation equation. The reason is that R&D data at the industry level are not available for Jordan and Mexico. As argued in Coe et al. (1997) and Schiff et al. (2002), given that 95% or more of all R&D spending takes place in the OECD countries considered, this is

4 These include studies at the country level such as Coe et al. (1997) for developing countries, and Engelbrecht (1997) and Lumenga-Neso et al. (2005) for OECD countries. Industry-level analyses for developing countries were conducted by Schiff et al. (2002), Schiff and Wang (2006) and Wang (forthcoming).

unlikely to bias our results.[5] Also following Coe et al. (1997), we estimate the equations in first differences rather than in levels.[6]

The estimated equation is:

$$\Delta \log TFP_{cit} = \beta_0 + \beta_{JPN} \Delta \log NRD_{cit}^{JPN} + \beta_{NA} \Delta \log NRD_{cit}^{NA} + \beta_{EU} \Delta \log NRD_{cit}^{EU}$$

$$+ \sum_t \beta_i I_i + \sum_i \beta_t D_t + \varepsilon_{cit}, \qquad (2)$$

where Δ denotes first differences, NRD^{JPN}, NRD^{NA}, and NRD^{EU} are defined in equation (1), I_i (D_t) denotes the industry (year) dummy capturing industry (year) fixed effects, and ε_{cit} is a white noise error term. We would expect β_{JPN}, β_{NA} and β_{EU} to be nonnegative. Moreover, if there is strong regional technology diffusion, we would expect β_{JPN} to be the largest and most precisely estimated for Korea, β_{NA} largest for Mexico, and β_{EU} largest for Jordan.

3. Data Description

The database consists of the three importing countries in the South (Korea, Mexico and Jordan), 16 manufacturing industries, 14 OECD trading partners, covering 22 years (1976-1997) for Korea and 18 years (1981-1998) for Mexico and Jordan. The selection of the manufacturing industries, the OECD trading partners, and the year

[5] In 1990 (1995), 96% (95%) of the world's R&D expenditures took place in industrial countries. Moreover, recent empirical work has shown that much of the technical change in individual OECD countries is based on the international diffusion of technology among OECD countries. For instance, Eaton and Kortum (1999) estimate that 87% of French growth is based on foreign R&D. Since developing countries invest much fewer resources in R&D than OECD countries, foreign R&D must be even more important for developing countries as a source of growth.

[6] Education variables (such as the share of the population with a given level of education) could be used as proxy for countries' absorption capacity. However, this variable does not vary across industries and is thus correlated with industry dummies. Also, the education variable changes very little over time (not at all in some cases), and given that our estimation is in first differences, we have two reasons not to include that variable in the estimation.

coverage is determined by data availability. The 16 manufacturing industries are either at the two-digit or three-digit level according to the International Standard Industry Classification (ISIC), revision 2.[7]

The TFP index is calculated as the difference between the logs of output and factor income, with inputs (labor and capital) weighted by their income shares, i.e., $\log TFP = \log Y - \alpha \log L - (1-\alpha)\log K$, with α equal to labor's share, measured as the ratio of wages over value added. The capital stocks are derived from the investment series using the perpetual inventory model with a 5% depreciation rate. Raw data on value added, labor, wages, and fixed capital formation are taken from the World Bank (Nicita and Olarreaga 2001), and were converted to 1990 US dollars, before computing the TFP index.

The R&D flow data are taken from the ANBERD 2000 (OECD) database (DSTI/EAS Division). It covers 15 OECD countries from 1973 to 1998 at either the two-, three- or four-digit level. From this, we construct R&D flow data for the 16 manufacturing industries at the two- or three-digit level (according to the United Nations International Standard Industrial Classification (ISIC), Revision 2). R&D flows cover all intramural business enterprise expenditures. Cumulative R&D stocks are derived using the perpetual inventory method with a 10% depreciation rate.

The national input-output matrix is used as a proxy, which is derived from GTAP (1998). Bilateral openness shares are derived from the World Bank database "Trade and

[7] They are: (1) 31 Food, Beverage & Tobacco; (2) 32 Textiles, Apparel & Leather; (3) 33 Wood Products & Furniture; (4) 34 Paper, Paper Products & Printing; (5) 351/2 Chemicals, Drugs & Medicines; (6) 353/4 Petroleum Refineries & Products; (7) 355/6 Rubber & Plastic Products; (8) 36 Non-Metallic Mineral Products; (9) 371 Iron & Steel; (10) 372 Non-Ferrous Metals; (11) 381 Metal Products; (12) 382 Non-Electrical Machinery, Office & Computing Machinery; (13) 383 Electrical Machinery and Communication

Production 1976-1998" (Nicita and Olarreaga, 2001). For each industry and year, the shares are measured as the ratio of industry-specific imports over value added. Trade data were collected at the 4-digit level and input-output data at the 3-digit level for the period 1981-98 (information on earlier years is available for Korea but not for the other countries), and both were aggregated to 2-digit and 3-digit levels for consistency with the R&D data (16 industries).

Table 1 shows that each developing country imports more from its Northern neighbor than from more distant OECD regions. On average over the period 1981-1998, out of its total imports from the three OECD regions, Mexico imported 82% from North America, 13% from the EU and 5% from Japan; Korea imported about 43% from Japan, 36% from North America and 21% from Europe; and Jordan imported 50% from the EU, 31% from North America and 19% from Japan.

Thus, both in terms of trade volume and in terms of distance, Korea (Mexico) (Jordan) is a "natural trading partner" of Japan (North America) (the EU). As for trade-related R&D stocks, each developing country gets access to more of the technology from its Northern neighbor than from more distant OECD regions.

4. Empirical Results

We now proceed with the estimation of the impact of trade-related technology diffusion from each OECD group on the TFP of each of the three developing countries and examine whether these impacts vary by country and by OECD group. Estimation is carried out in first differences and with the White heteroskedasticity-consistent estimator.

Equipment; (14) 384 Transportation Equipment; (15) 385 Professional Goods; and (16) 39 Other

Tables 2, 3 and 4 report for Korea, Mexico and Jordan, respectively, the impact on TFP of trade-related technology diffusion (*NRD*) from the three OECD regions. Columns (i) to (iii) report the impact on TFP of *NRD* from each OECD region separately, columns (iv) to (vi) report the joint impact on TFP of *NRD* from two of the three OECD regions, and column (vii) reports the impact on TFP of *NRD* from the three OECD regions. Coefficients for the constant and for the time and industry fixed effects are not shown. F-tests indicate that year (industry) dummies do (do not) need to be included in the regressions. Our prior is that the elasticity of TFP with *NRD* is non-negative so that a one-tailed test is appropriate.

4.1. Korea

Columns (i) to (iii) of Table 2 show the elasticity of TFP with respect to the *NRD* from one OECD region at a time. The elasticity of TFP with respect to Japan's *NRD* is .52, significant at the 5 percent level. That with respect to EU's *NRD* is .21 but not significant and with respect to North America's *NRD* is .03 and not significant. The latter is perhaps somewhat surprising, given that North America accounts for 36.5% of Korea's imports over the period (Table 1). Note though that the R&D-content of Korea's imports from Japan is greater than that of imports from the US (see Table 1).[8]

Columns (iv) to (vi) report effects of *NRD* from two of the three OECD regions at a time. The elasticity with respect to Japan's *NRD* is .47 in a regression with the EU's *NRD* (column iv) and .51 in a regression with North America's *NRD* (column v), both significant at the 5% level, while the elasticities with respect to the EU's and North

Manufacturing.

America's *NRD* are not significant (column vi). These results confirm those obtained in columns (i) to (iii).

Column (vii) reports the effects of the *NRD* from the three OECD regions simultaneously. The elasticity of TFP with respect to *NRD* from Japan is .47, significant at the 5 percent level, while the elasticities of TFP with respect to *NRD* from North America and from the EU are small and not significant. These results confirm those in columns (i) to (vi).

The same results obtain with one-tailed tests. The elasticities of *NRD* from North America and from the EU continue to be non-significant, while the elasticity of *NRD* from Japan is significant at the 2.5% level.

The results obtained are extremely robust since they provide identical results under three alternative specifications – i.e., regressions with one country, two countries, and with all three countries – as well as with two statistical tests of significance (one-tailed and two-tailed tests).

4.2. Mexico

Similarly, the results in Table 3 give a consistent message across all three specifications and the two statistical tests. The elasticity of TFP with respect to the *NRD* from North America varies between .55 and .61, significant at the 10 percent level (with one of them at the 13% level), while the elasticities with respect to *NRD* from Japan and the EU are not significant.

[8] Imports from Japan are 17% higher than those from the US, while their R&D content --weighted by trade shares --is 43% higher, implying a 22% higher R&D content.

We further examine whether NAFTA had an impact on any of the parameter values. This was tested in two alternative ways. First, a dummy variable, with value equal to one for the NAFTA years and zero otherwise, was added to the estimating equations of Mexico's TFP and turned out to be non-significant. Second, the sample period was shortened to the pre-NAFTA period 1981-1993 and resulted in a small and non-significant change in elasticity values. For instance, the elasticity of TFP with respect to *NRD* from North America in the regression with *NRD* from Japan and the EU (column vii) changed from .603 to .628.

4.3. Jordan

Our objective was to select an NTP of the EU. The obvious choice was an Eastern European country and we estimated regressions for two countries for which data were available. These countries underwent a major shock during the period examined, with the demise of the Soviet bloc leading to massive institutional, political and economic changes – including a massive redirection of their trade towards the West. This probably explains why the elasticities were unreasonably large for these countries.

Given that the results for those countries were dominated by the massive changes they experienced over the sample period, we decided to select another country. Jordan was chosen because of its data availability, small distance to the EU, and FTA with the EU. The estimation results are presented in Table 4.

Table 4 shows that the elasticity of TFP with respect to *NRD* from North America is never significant. The elasticity of TFP with respect to *NRD* from Japan is significant when appearing by itself (column i) or with the *NRD* from North America (column iv) but is not significant when used together with the *NRD* from the EU (column v) or with both those from the EU and North America (column vii). Thus, once the *NRD* from the EU is included in the regression, the *NRD* from Japan loses its statistical significance and becomes very small empirically.

The elasticity with respect to *NRD* from the EU is significant at the 5% level when appearing by itself (column 3) or with the *NRD* from North America (column vi), and is significant at the 11% when appearing with the *NRD* from both Japan and North America (column vii). Moreover, given our strong prior of non-negative coefficients, one-tailed tests are warranted and indicate a significance level of less than 10% in column (vii). On the other hand, the *NRD* from Japan and from North America continue to be non-significant under one-tailed tests in regressions that include the *NRD* from the EU.

5. Interpretation of the Results

The empirical results described above are striking. For all three developing countries, the highest and most precisely estimated elasticity of TFP is the one with respect to *NRD* from its neighboring OECD region or "natural trading partner." Thus, our results indicate that North-South trade-related technology diffusion exhibits a strong regional pattern. Why is the impact of *NRD* from the neighboring OECD region so much bigger than that from the distant regions?

One possibility is that trade between each country in the South and its OECD neighbor involves more than a simple exchange of goods. It is likely to entail more personal interaction, including sub-contracting relationships where firms in the developing country import intermediate goods from firms in the neighbor in the North and export finished products back to the same firms, as in the automobile industry. In that case, knowledge diffusion is associated not only with the knowledge-content of the goods traded but also with the close contacts associated with that trade and the quality controls that firms in the North impose on their sub-contractors in the South, as well as with the transfer of knowledge on improving production processes and overall management. Such hands-on relationships are more likely to hold between neighboring countries than between distant ones where arms-length relationships are more likely to prevail.

Moreover, proximity between firms in the North and their subcontractors tends to facilitate the formation of hands-on relationships. Since such relationships make it easier to exercise control over production processes and output quality, it should be easier for developed countries' firms to transfer more complex technological knowledge to subcontractors in proximate developing countries than to more distant ones and have them produce more technology-intensive products.[9] This line of research will be pursued in future research by distinguishing between industries according to their R&D-intensity.

An alternative hypothesis for the fact that the impact on developing countries' TFP is mainly obtained through trade with their closest OECD region is that it is determined by the *level* of *NRD*.[10] However, there is no a priori theoretical reason why the *level* of *NRD* should have an impact on the *elasticity* of TFP growth with respect to *NRD*. Moreover, we are dealing with TFP growth, and the regression is estimated in Δlog rather than in *log* form. Hence, there would seem to be even less reason for its coefficient to be related to the *NRD* level.

[9] Thanks are due to an anonymous referee for suggesting this hypothesis and the next one.
[10] The level of *NRD* differs in large part because of the difference in trade shares with the various regions.

If there were a theoretical reason for the elasticity of TFP growth with respect to *NRD* to be larger when the level of NRD is greater, one would expect it to hold in most if not all cases. However, this does not seem to be the case, as the two following examples illustrate. For instance, Korea's *NRD* from trade with Japan (NRD_{JK}) is the largest (see Table 1), and its impact on TFP growth is also the largest and is significant at the 5% level. However, even though Korea's *NRD* from trade with North America (NRD_{NK}) is large as well, its impact on TFP growth is non-significant, both empirically and statistically.

The dramatic difference, in fact, is in the distance from Korea to Japan (D_{JK}) versus the distance to North America (D_{NK}). Table 1 shows that D_{JK} is equal to 1,157 km while D_{NK} is equal to 11,066 km. Thus, the proportional difference (D_{NK} - D_{JK})/D_{JK} is equal to 8.5. Comparing the percentage difference in distance (850%) versus that in *NRD* (30%), we obtain a ratio of 28.3. Another case is that of Jordan, where the *NRD* from Japan is 12% smaller than that from the EU but its distance to Jordan (9,096 km) is 2.83 times that from the EU (3,203 km), with the proportional difference in distance between Japan and the EU relative to that in *NRD* equal to 15.3.

Thus, it seems that what explains the results is essentially the large difference in the distance between developing and developed countries.

6. Concluding Remarks

This paper examined a dynamic version of the "natural trading partners" hypothesis by estimating the impact of trade-related technology diffusion from three developed OECD regions – Japan, North America and the EU – on productivity in Korea, Mexico and Jordan. Using industry-level data, the paper shows that trade-related technology diffusion and productivity gains in the three countries tend to be regional. We find that, in terms of productivity gains, Korea seems to benefit mainly from trade with Japan, Mexico from trade with North America, and Jordan from trade with the EU. These findings support the hypothesis that the dynamic version of the "natural trading partners" hypothesis holds for these groups of countries.

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Table 1: Manufacturing Imports and Trade-related R&D from each Region (1981-1998 average)

Country	Trading Partner	Import Share (%)	Distance (km)	Trade-related R&D
Korea	European Union	20.57	8,544	7.52E+07
	Japan	42.93	1,157	5.32E+08
	North America	36.50	11,066	3.70E+08
Mexico	European Union	12.92	9,400	1.06E+08
	Japan	5.11	11,312	9.02E+07
	North America	81.97	3,369	2.57E+09
Jordan	European Union	50.22	3,203	1.98E+10
	Japan	19.13	9,096	1.73E+10
	North America	30.65	9,210	1.03E+10

Note: Figures reported are averages for 1981-1998. Trade-related R&D from each region is defined as in equation (1) and figures reported are averages for 1981-1998. For distance, Germany is used for the EU and the US for North America (defined here as the US and Canada).

Table 2: Determinants of TFP – Korea
(Dependent variable: $\Delta\log TFP$, 1976-1997)

Variable	(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)
$\Delta logNRD^{JPN}$	0.52**			0.51**	0.47**		0.47**
	(2.11)			*(2.08)*	*(2.03)*		*(2.01)*
$\Delta logNRD^{NA}$		0.03		-0.00		0.01	0.01
		(0.19)		*(-0.02)*		*(0.17)*	*(-0.03)*
$\Delta logNRD^{EU}$			0.21		0.15	0.20	0.15
			(0.90)		*(0.61)*	*(0.86)*	*(0.61)*
F-test (P-value)							
No Time Effects	0.00	0.00	0.00	0.00	0.00	0.00	0.00
No Industry Effects	0.63	0.71	0.71	0.63	0.63	0.70	0.63
Obs	336	336	336	336	336	336	336
Adjusted R^2	0.48	0.46	0.47	0.48	0.48	0.47	0.48

Note: $\Delta logNRD^{JPN}$, $\Delta logNRD^{NA}$ and $\Delta logNRD^{EU}$ are the first difference of the logs of trade-related technology from trading with Japan, North America, and the EU, respectively. Figures in parentheses are robust t-statistics. The data set consists of 16 manufacturing industries in Korea with 15 OECD trading partners, and covers 1976-1997. Regression results on constant, time and industry dummies are not reported. ** means a 5% significance.

Table 3: Determinants of TFP – Mexico
(Dependent variable: Δlog*TFP*, 1981-1998)

Variable	(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)
$\Delta logNRD^{JPN}$	**0.24**			**-0.14**	**0.17**		**-0.20**
	(0.77)			*(-0.53)*	*(0.44)*		*(-0.92)*
$\Delta logNRD^{NA}$		**0.57***		**0.61***		**0.56^{+}**	**0.60***
		(1.65)		*(1.66)*		*(1.58)*	*(1.65)*
$\Delta logNRD^{EU}$			**0.29**		**0.18**	**0.02**	**0.12**
			(0.95)		*(0.67)*	*(0.07)*	*(0.50)*
F-test (P-value)							
No Time Effects	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
No Industry Effects	**0.97**	**0.98**	**0.95**	**0.97**	**0.96**	**0.98**	**0.97**
Obs	**272**	**272**	**272**	**272**	**272**	**272**	**272**
Adjusted R^2	**0.42**	**0.50**	**0.43**	**0.51**	**0.43**	**0.51**	**0.52**

Note: $\Delta logNRD^{JPN}$, $\Delta logNRD^{NA}$ and $\Delta logNRD^{EU}$ are the first difference of the logs of trade-related technology from trading with Japan, North America, and the EU, respectively. Figures in parentheses are robust t-statistics. The data set consists of 16 manufacturing industries in Mexico with 15 OECD trading partners, and covers the period 1981-1998. Regression results on constant, time and industry dummies are not reported. * (+) means a significance level equal to 10 (13) %.

Table 4: Determinants of TFP – Jordan
(Dependent variable: $\Delta\log TFP$, 1981-1998)

Variable	(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)
$\Delta logNRD^{JPN}$	0.59**			0.57**	0.17		0.09
	(2.12)			(2.10)	(.42)		(.12)
$\Delta logNRD^{NA}$		0.43		0.21		0.33	0.34
		(.76)		(.41)		(.66)	(.49)
$\Delta logNRD^{EU}$			0.64**		0.51	0.63**	0.56^
			(2.22)		(1.32)	(2.18)	(1.61)
F-test (P-value)							
No Time Effects	0.00	0.00	0.00	0.00	0.00	0.00	0.00
No Industry Effects	0.00	0.19	0.00	0.00	0.00	0.00	0.00
Obs	0.29	0.27	0.30	0.29	0.30	0.30	0.30
Adjusted R^2	0.23	0.22	0.23	0.23	0.22	0.23	0.23

Note: $\Delta logNRD^{JPN}$, $\Delta logNRD^{NA}$ and $\Delta logNRD^{EU}$ are the first difference of the logs of trade-related technology from trading with Japan, North America, and the EU, respectively. Figures in parentheses are robust t-statistics. The data set consists of 16 manufacturing industries in Jordan with 15 OECD trading partners, and covers the period 1981-1997. Regression results on constant, time and industry dummies are not reported. **(^) means a significance level equal to 5 (12) %.